Analysis of Mirror Deformation and Sparse Actuator Spacing

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We have studied three cases of mirror deformation using both IMOS and Nastran:

1. Radius of curvature error

2. Gravity load deformation

3. Thermal (will be presented by C. Perrygo)

What are the issues that affect acutator density?

1. Thickness of mirror

2. Mirror material properties

3. Scale length of deformation to be corrected

Sparse actuation of “relatively thick” plates works because:

1. The equation for a sphere is $z \quad r^2 / R$ where $r = \sqrt{x^2 + y^2}$; $\quad R \equiv ROC$ and for $r / R << 1$;

2. The equation of deflection for a flat plate (disc) with simple fixed supports at the edge and a single force at the center is:
   $z \quad f\left[\kappa(l^2 - r^2) - 2r^2 \log(l / r)\right]$
   where e l is the radius of the plate ;

3. Plots show that for the 16mm thick case with ROC=20m the deflection is roughly quadratic – curved plate deflects like a flat plat and deflection matches the equation for a sphere;

4. Deflected shape and desired shape are roughly the same.

Conclusions from this study are:

1. Sparse acuators work for correcting ROC error for “thick” mirrors

2. Local deformation limits effectiveness of sparse actuators for “thin” mirrors

3. If gravity load is to be corrected more actuators are needed

Future work will be focused on:

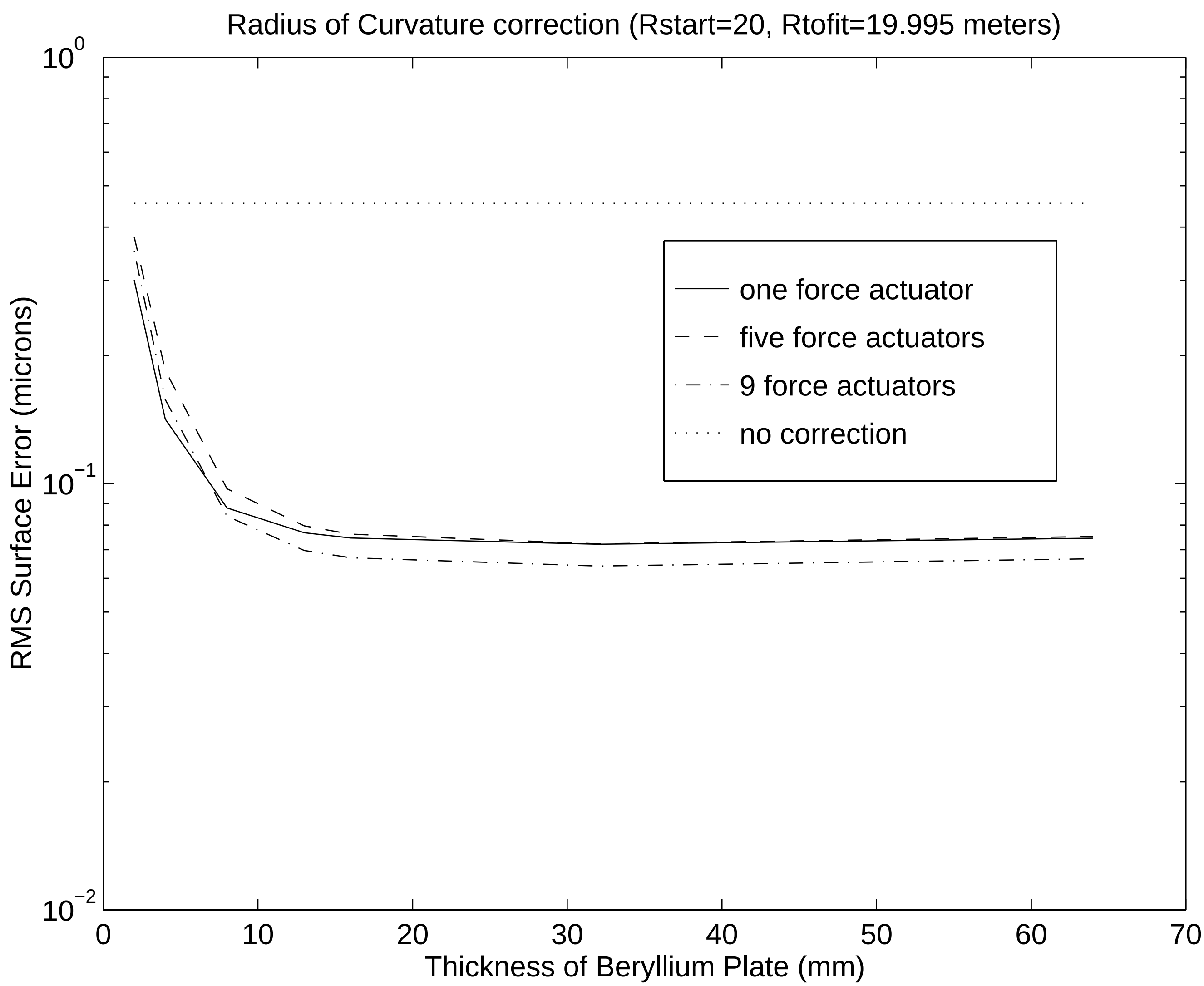
1. Making more realistic petal models

2. Optimizing placement and number of actuators

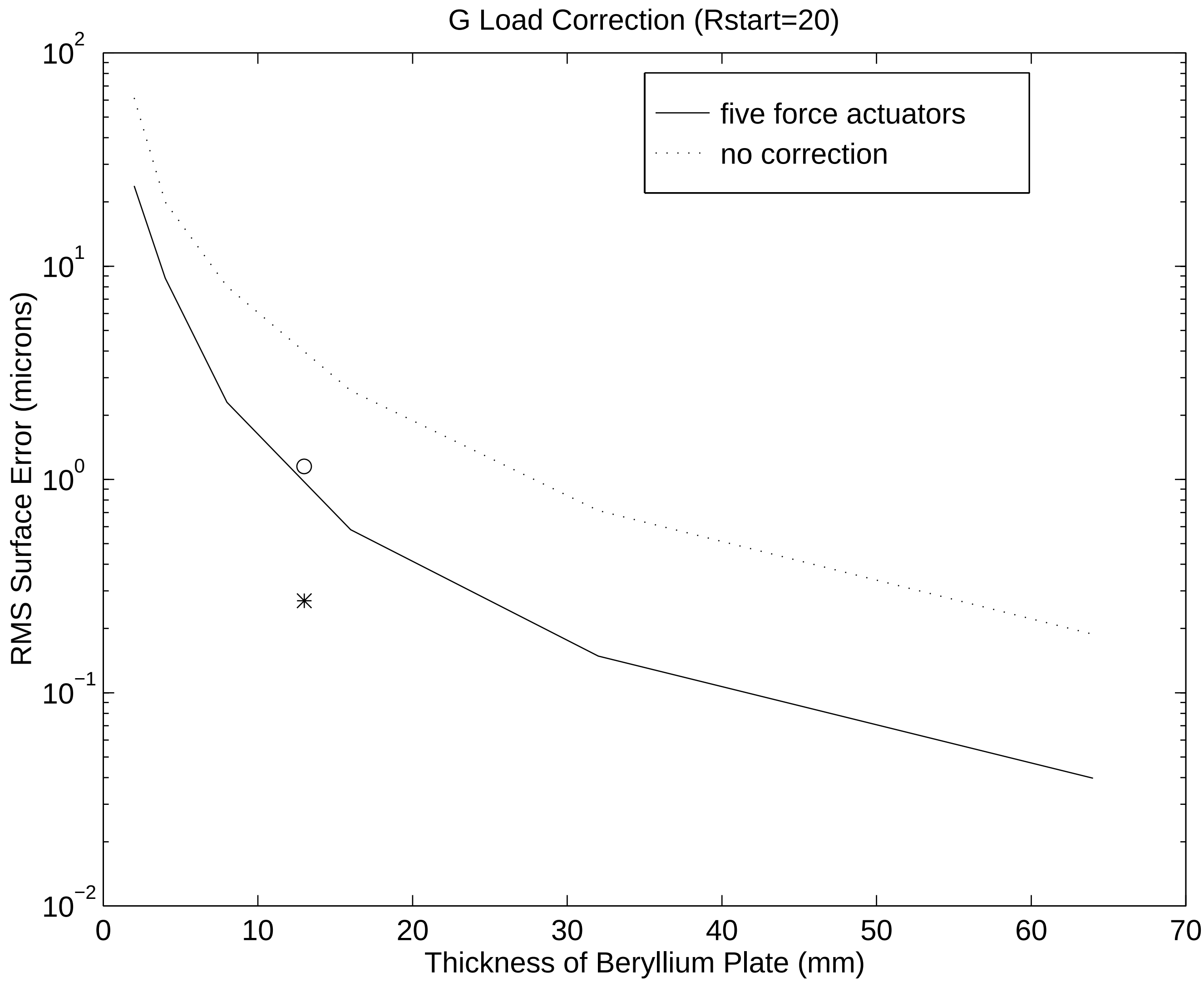
3. Studying high density actuators for the “thin” mirror case

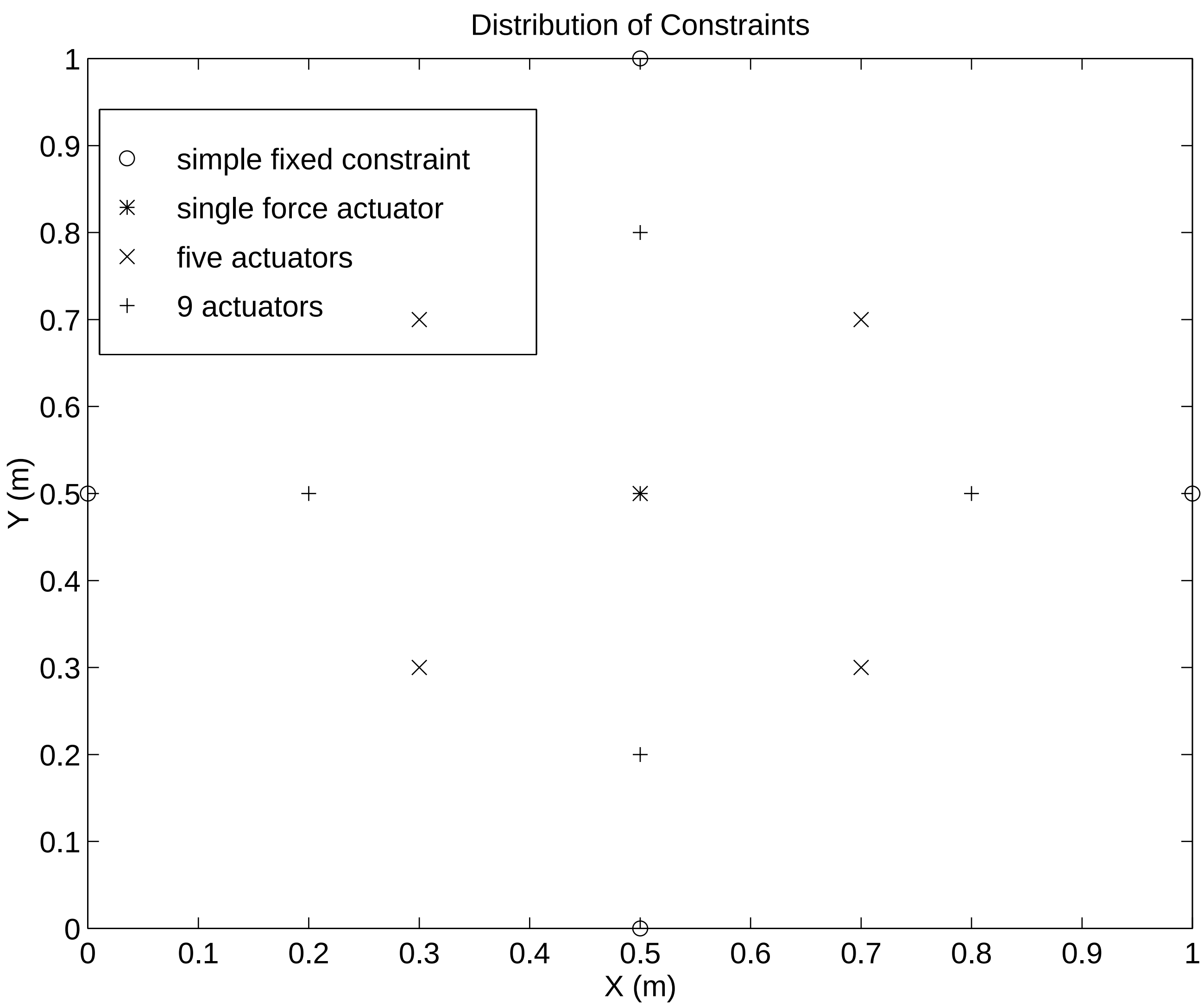
4. Make detailed error budget for Radius of Curvature error

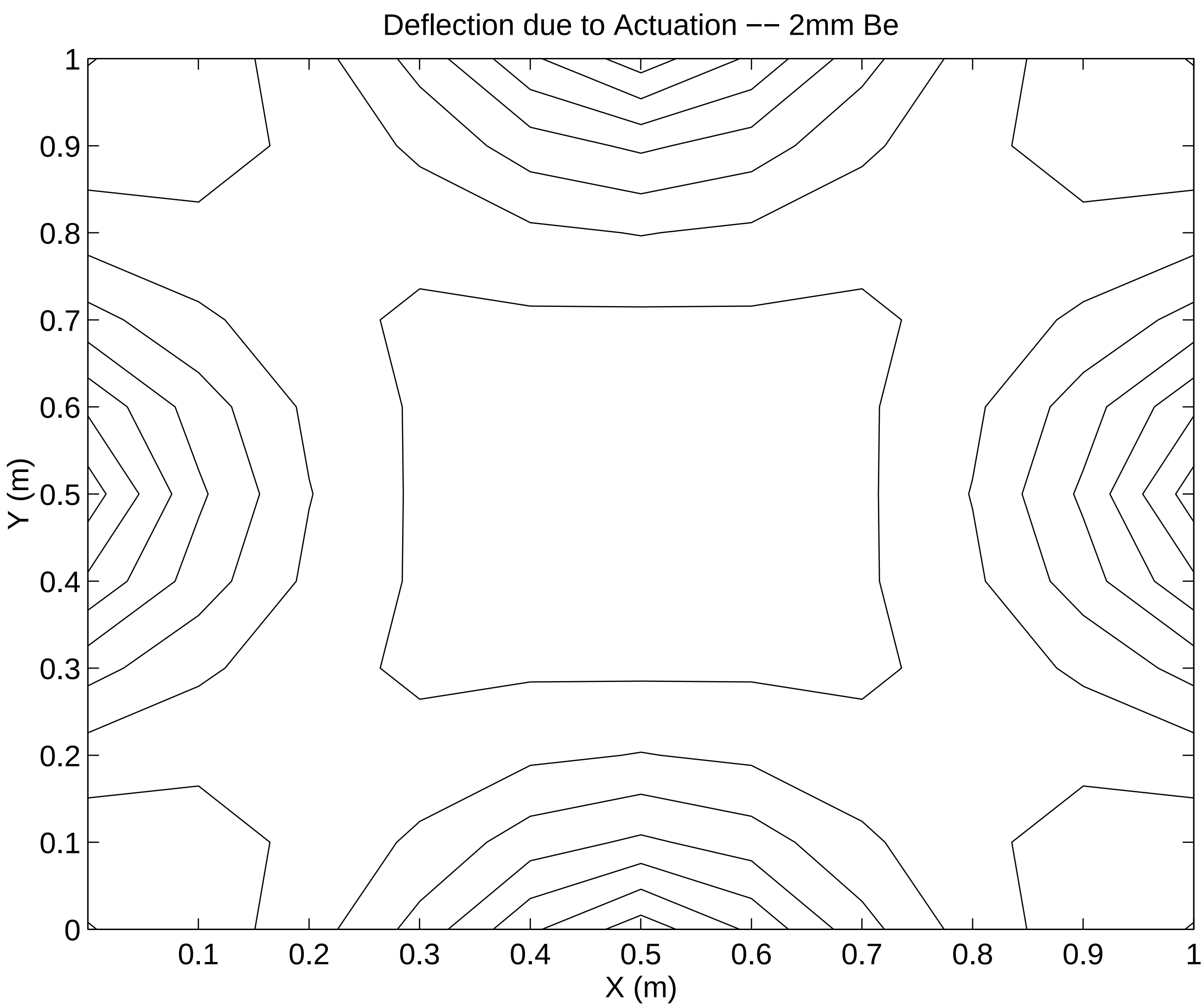
5. Estimate and correct higher order aberrations

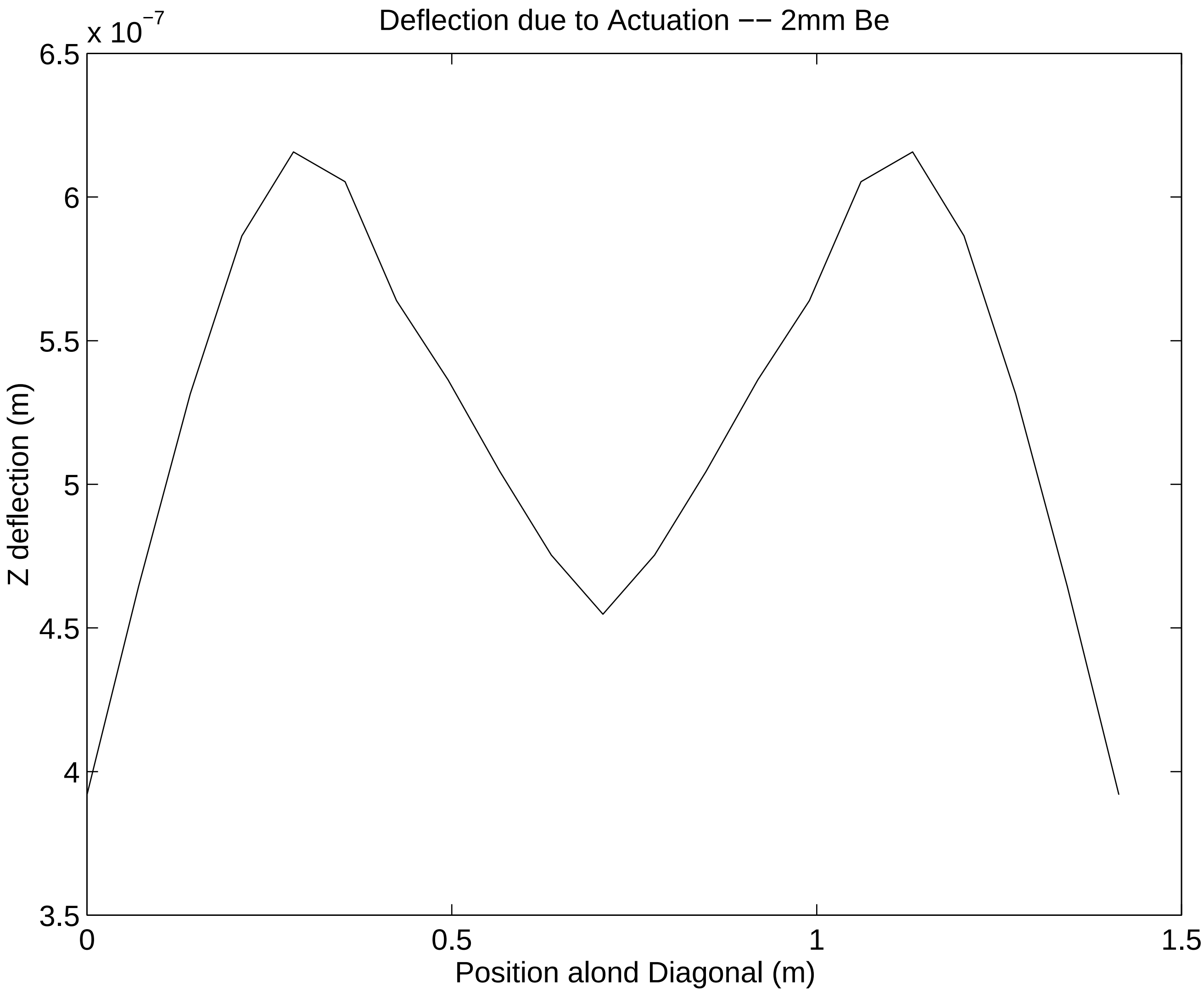


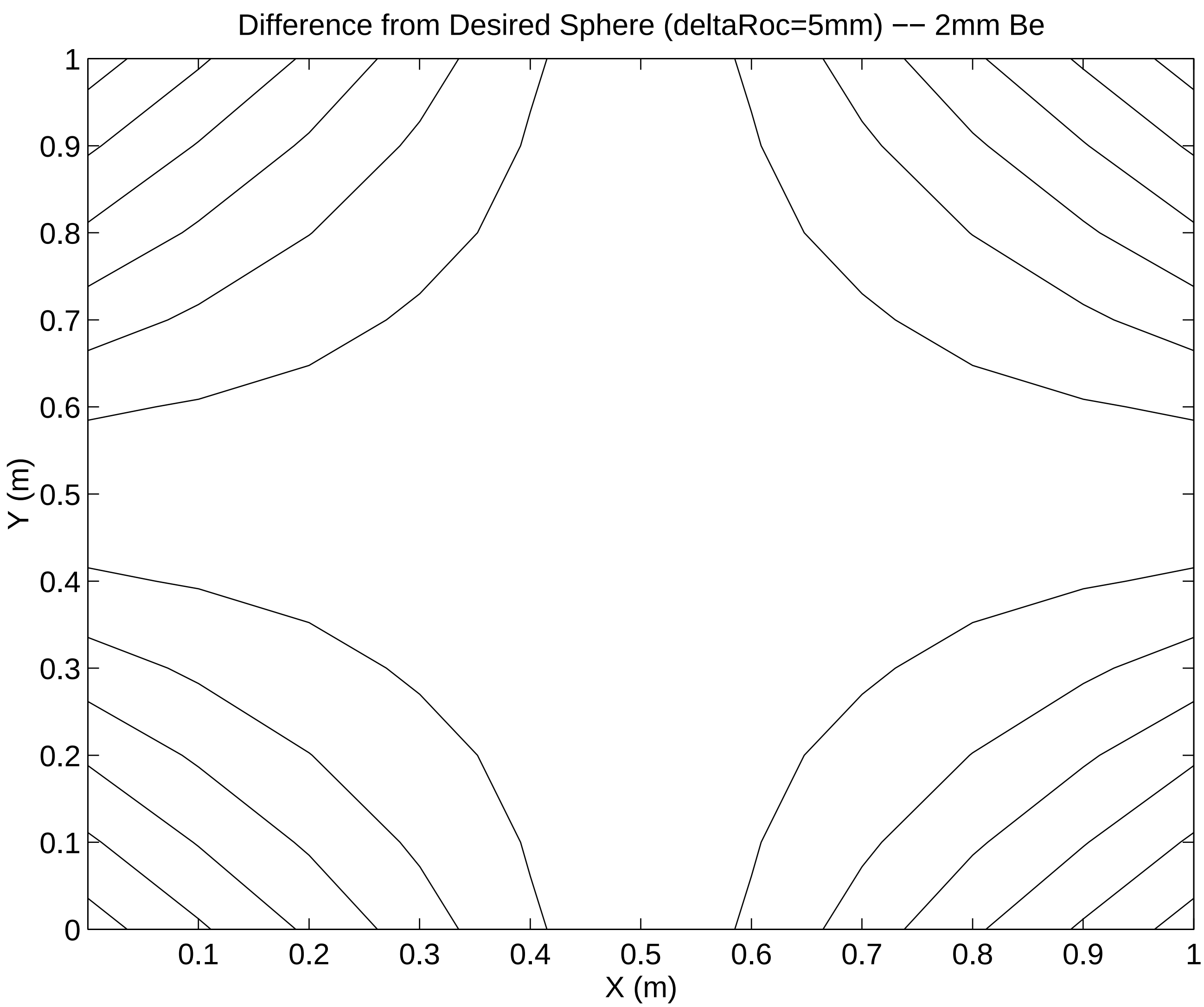
Radius of Curvature correction (Rstart=20, Rtofit=19.995 meters)
RMS Surface Error (microns)
Thickness of Beryllium Plate (mm)
10^0
10^{-1}
10^{-2}
0
10
20
30
40
50
60
70
one force actuator
five force actuators
9 force actuators
no correction

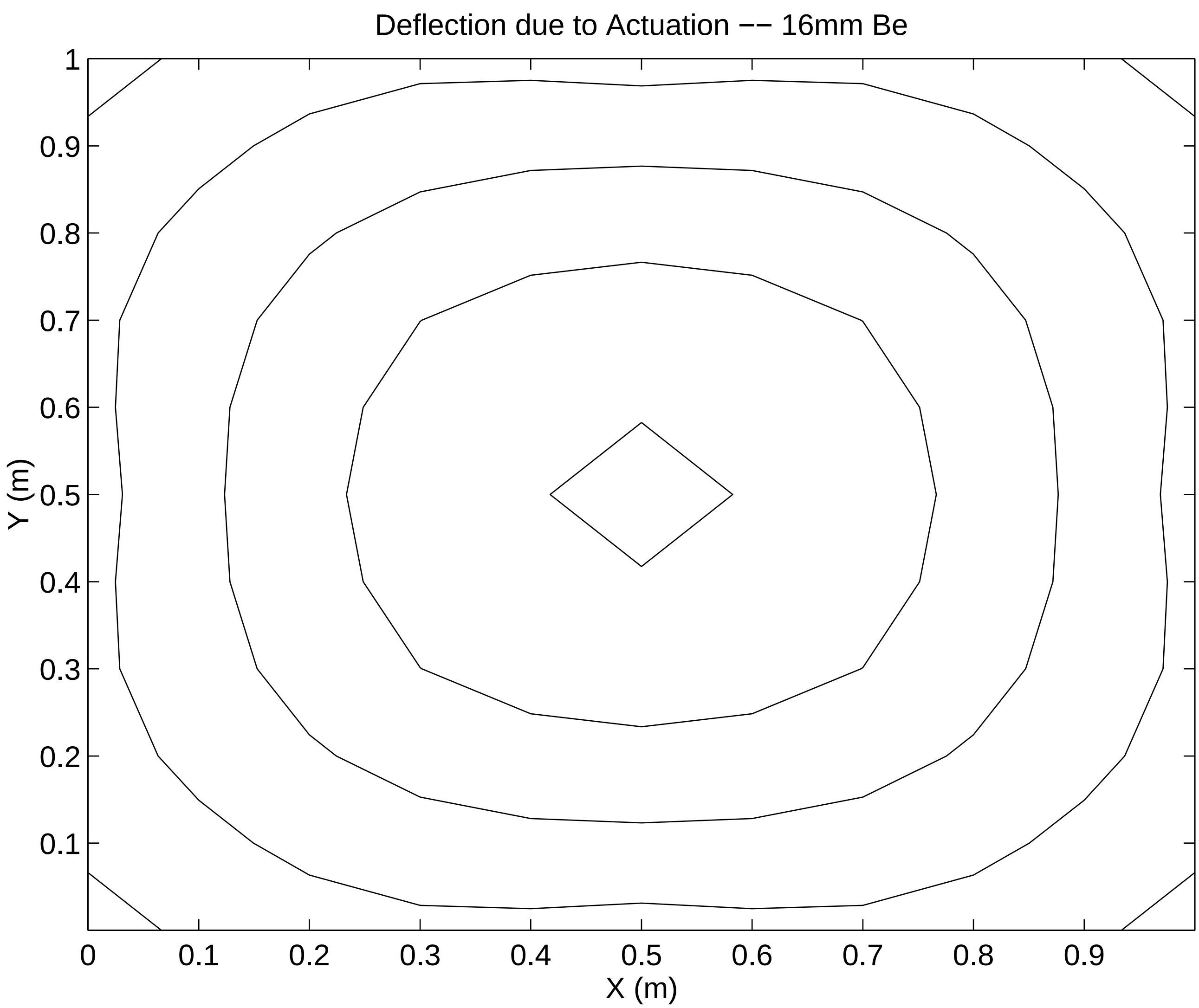

G Load Correction (Rstart=20)
five force actuators
no correction
RMS Surface Error (microns)
10^{2}
10^{1}
10^{0}
10^{-1}
10^{-2}
0
10
20
30
40
50
60
70
Thickness of Beryllium Plate (mm)

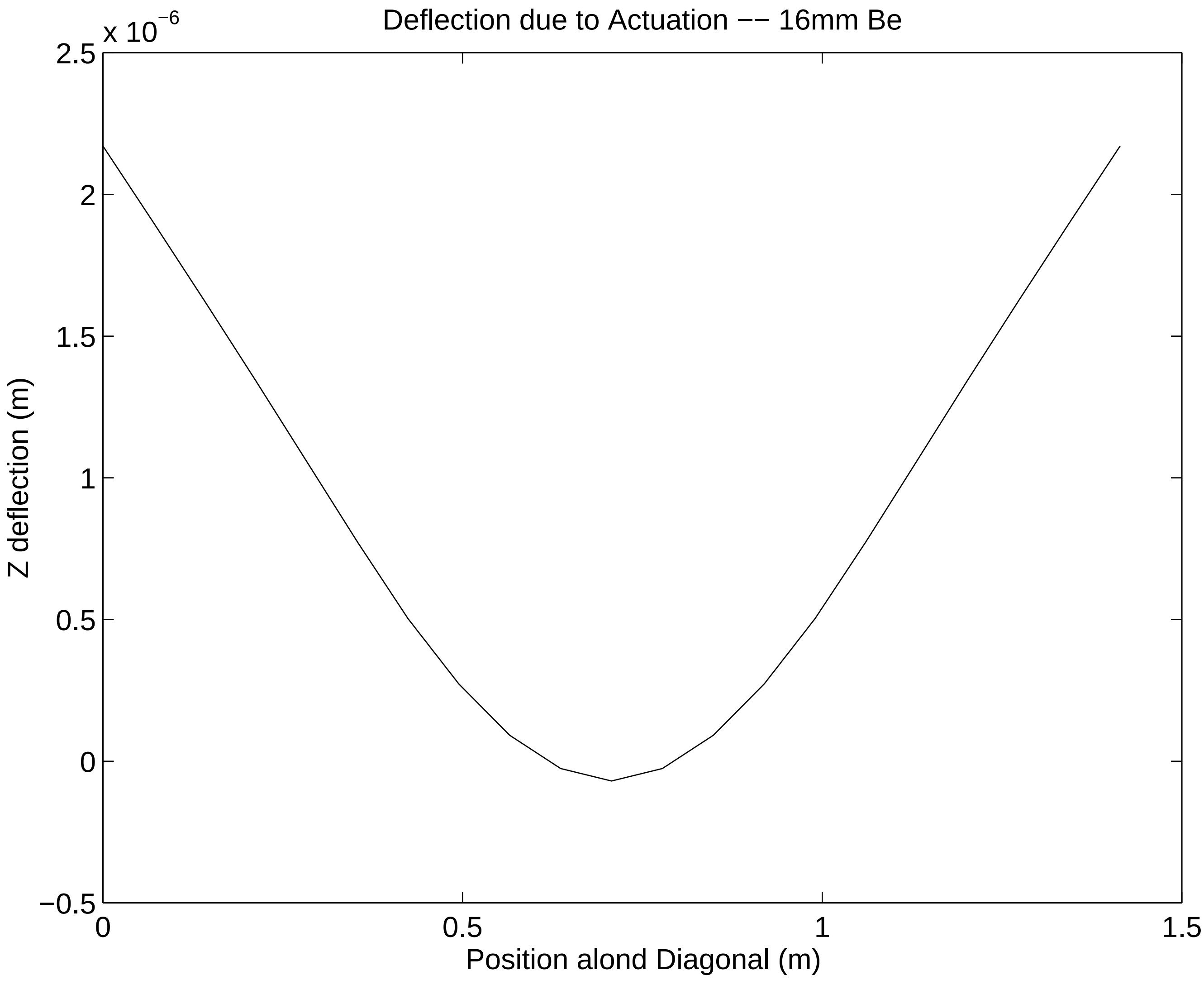

Distribution of Constraints
simple fixed constraint
single force actuator
five actuators
9 actuators
X (m)
Y (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1

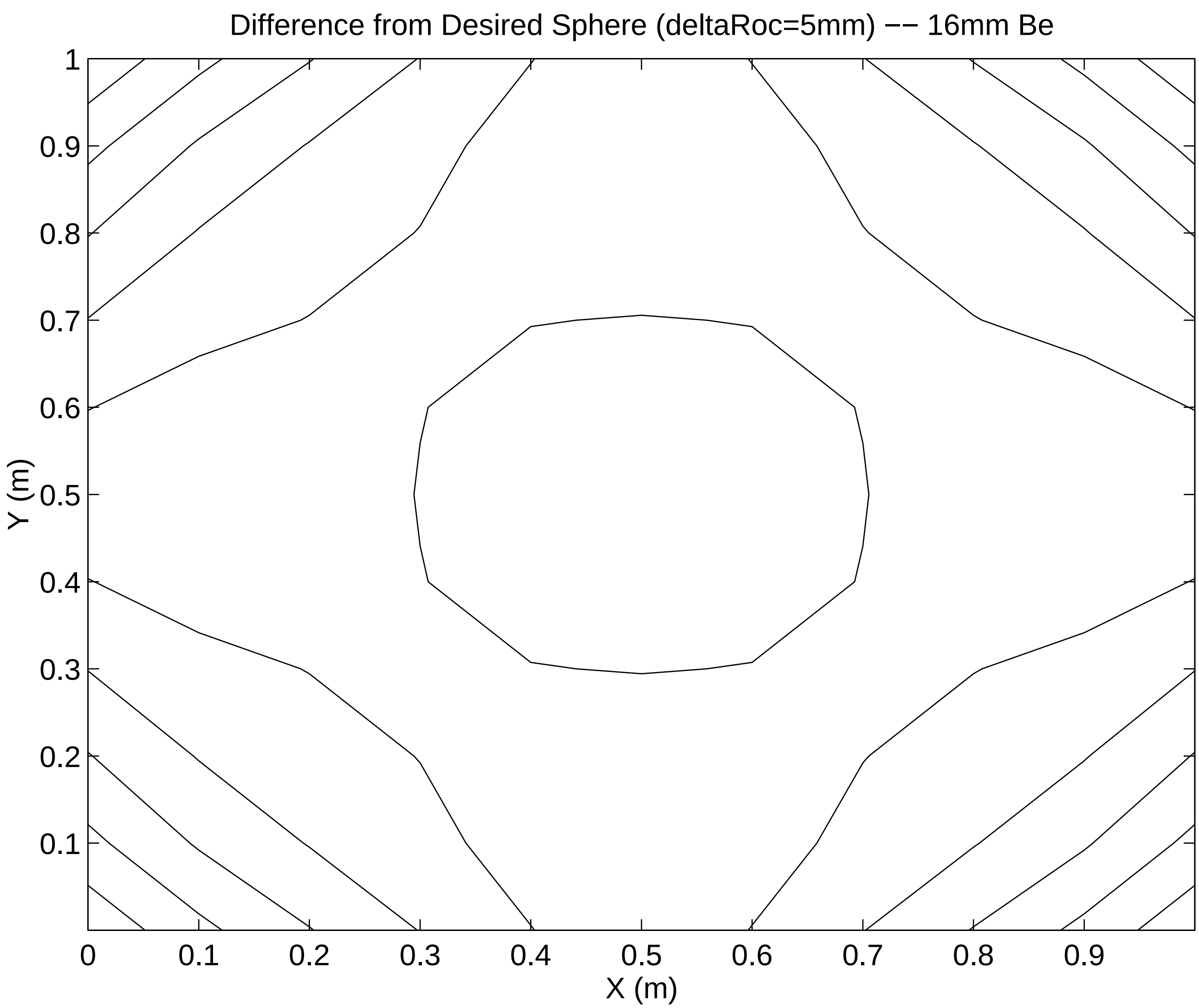

Deflection due to Actuation -- 2mm Be
Y (m)
X (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Deflection due to Actuation −− 2mm Be
x 10^−7
6.5
6
5.5
5
4.5
4
3.5
Z deflection (m)
0
0.5
1
1.5
Position alond Diagonal (m)


Difference from Desired Sphere (deltaRoc=5mm) −− 2mm Be
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
Y (m)
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
X (m)


Deflection due to Actuation -- 16mm Be
Y (m)
X (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1


Deflection due to Actuation −− 16mm Be
x 10^−6
2.5
2
1.5
1
0.5
0
−0.5
Z deflection (m)
0
0.5
1
1.5
Position alond Diagonal (m)


Difference from Desired Sphere (deltaRoc=5mm) −− 16mm Be
Y (m)
X (m)
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1